SEE Bulletin

Developing Tomorrow's Space Technologies Today

NASA's Space Environments and Effects Program | Fall 1998 Issue

SEE Program

With the end of another fiscal year behind us, I would like to reflect on the many accomplishments of the Space Environments & Effects (SEE) Program, and the vast opportunities which lie ahead of us. The accomplishments are the result of the hard work of the many individuals, both within NASA and outside of NASA, who make up the SEE Team. I also want to familiarize you with the roles carried out by various members of the SEE Program Office.

We accepted the challenge of NASA Headquarters by fully competing our FY98 and FY99 funding by coordinating a peer review of 67 technical proposals to develop advanced SEE technologies. From these outstanding proposals, 12 technology development activities were selected and the technology development has began on each of these. Ms. Carolyn Goodloe, of the SEE Program Office, represents the SEE community and the SEE Program as the end customer for each of these technologies. We have also began preparations for a new NASA Research Announcement (NRA) to be released during the summer of 1999 to compete our anticipated FY2000 funding. The actual amount of this funding is still not firm and will not be for several months. Ms. Lisa Tyree, of the SEE Program Office, will work with the SEE Program Manager, SEE Technical Working Group Chairpersons and SEE User Steering Committee in coordinating the 1999 NRA release and the ensuing evaluation process.

With the exception of our technology development activities, the most significant accomplishment during FY98 may have been the SEE Program's enhanced collaboration with other Government agencies. Of particular note has been our leadership of the Space Environmental Effects Working Group as a part of the NASA / USAF Partnership Council. Significant progress has been made on several tasks in the areas of Space Radiation, Plasma & Spacecraft Charging, and Thermosphere and Solar Activity. Billy Kauffman, of the SEE Program Office, leads these and other collaborative efforts with organizations outside of NASA for the SEE Program.

During FY98 the SEE Program also made great strides in continuing to promote flight experiment advocacy for the SEE community. Stu Clifton, of the SEE Program Office, coordinates multiple efforts in this area for the NASA SEE community. Of particular note was the development of the NASA Radiation & Electronics Testbed (NASRET) which will fly on the Space Technology Research Vehicle (STRV1-d) in 1999. Mr. Clifton also did an outstanding job of leading an agency-wide trade study of the feasibility of an Orbiting Technology Testbed Initiative (OTTI). We are in hopes that this initiative will be fully funded in 2000, with a potential start-up in 1999.

A major change which effects the SEE Program was recently implemented at NASA Headquarters. The Advanced Technology & Mission Studies Division in the Office of Space Science has reorganized. This is the organization which sponsors the SEE Program's cross-cutting technology development. Jody Minor, of the SEE Program Office, serves as the SEE Program's primary liaison with NASA

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Mir Solar Array Return Experiment

by James Visentine, Boeing

Late last year, a solar array panel was removed from the non-articulating PV (Photovoltaic) array on the Mir core module during a successful EVA by suited Russian cosmonauts. This panel, which was exposed to the orbital space environment for a period of over ten years, consists of eight foldable sections and was ~6.0 meters in length and ~1.3 meters in width. The length and width dimensions of the foldable sections were 69.5 cm and 122 cm, respectively. After removal from the PV Array, the solar panel was placed in a protective bag, sealed, and stowed within the Mir core module.

During the STS-89 mission to the Mir Orbital Space Complex in January 1998, this panel was removed from the Mir core module and stowed aboard the U.S. Spacehab module for return to Earth where detailed laboratory studies of the effects of prolonged space exposure could be conducted.

The location of the non-articulating PV array on the Mir core module from which the Russian panel was removed was located directly above the Kvant-2 Module and was extended outward from the Mir Core Module in a direction parallel to the “Sofora” truss on the Kvant-1 Module. The returned panel consisted of one of four wings which were deployed during a Russian EVA on June 16, 1987. This particular panel, which has experience prolonged (125 months) exposure to the orbital space environment, was later removed from the Mir core module by suited Russian cosmonauts on November 03, 1997.

A visual examination of the array after it was returned for post-flight inspection revealed it was highly contaminated by an opaque, white film which was deposited non-uniformly along the length of the panel on both the cover slides and the optical solar reflectors that were bonded to the silicon solar cells. Several localized regions of the eight panel sections were highly blackened, and the silicon cells within these regions appeared to have been damaged by electrical arcing or by high-current, over-temperature conditions which occurred when some active sections of the array surface were in shadow.

The metal frame and handrails for the array were originally coated with a Russian white thermal control paint. As a result of prolonged exposure to the orbital space environment, this paint was highly degraded in physical appearance, and its color had changed from a bright white to various hues of light and dark tan. An analysis of the chemical composition of this paint has revealed it contains the elements zinc, oxygen, silicon and carbon and is probably Russian AK-573 paint, whose components consists of silicone and acrylic binders with ZnO fillers.

Further examinations have indicated that molecular contaminants from a variety of external sources had outgassed and condensed on these painted surfaces and on other active and passive components of the solar array. With solar UV exposure, these contaminants were polymerized and fixed to the surfaces of these components. With further UV exposure, these contaminants began to darken, thereby increasing the solar absorptance and visual color of the coatings. Thicker layers of contaminants and longer duration exposures to UV radiation appear to have increased the degree of optical degradation.

Visual examinations of meteoroid and debris impacts, using a magnifying glass, of the front and rear surfaces of seven of the eight array sections were performed in the Spacehab laboratory clean room facility, and the location and relative size (small, medium and large) of ~1,500 impact features were observed and recorded. Digital photographs were then taken through a microscope of the medium and large features.

In summary, the number of impact features observed was consistent with expectations based on the number of features observed on the LDEF (Long Duration Exposure Facility) which was retrieved from orbit during the STS-32 mission; however, the damage observed at many impact sites was less than expected based on the LDEF damage observations. The complete array assembly was penetrated at 15 of the impact sites, however, the novel construction of the panels probably minimized the shock propagations at the impact sites and thus the damage to the impacted solar cell and the surrounding cells.

The individual panel sections of the Mir PV array were physically examined by the U.S. and Russian investigators to determine the type and design configuration of the solar cells and the circuit wiring architecture. Each section was individually wired to the array power connector. Using a high-intensity, photographic floodlight and a handheld digital multimeter, the U.S. investigators were able to measure both an open-circuit voltage and short-circuit current for each of the eight panels, thus confirming that the electrical continuity of each section has remained intact after 10 years exposure to the orbital space environment. The values obtained for the eight panel sections, while not indicative of actual performance, were grouped fairly closely together. Evidently, during operation aboard the Mir space station, no panel section had suffered a catastrophic failure, and the electrical performance of each of the sections declined at a similar degradation rate.

The overall energy conversion efficiency was determined to be 4.8% at an operating temperature of 25° C. Where the Russian wiring configuration allowed, smaller sections of the panel were further evaluated. During these tests, the best results were obtained from the circuit combinations of parallel cell columns 13-14-15. This unit (3 circuits parallel by 24 cells series) of the array had an energy conversion efficiency of 8.92%.

Follow-on Laboratory Studies

FTIR (Fourier Transform Infrared) spectroscopy measurements will be obtained of the exposed surfaces to

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Headquarters and Mission Integration Centers. What we know today as technology disciplines will be handled as "Thrust Areas" in the new organization.

As far as in-reach and outreach, we continue to strive to disseminate the products of the SEE Program into the NASA SEE community as quickly as possible. We are committed to continuing to promote U.S. preeminence in the space industry by providing our customers with the latest SEE technologies. One way we do this is through this newsletter which now has a distribution of over 750 persons who have indicated a desire to be kept aware of NASA's latest technologies in the area of space environments and effects. We also had the opportunity to share with our technical community at three conferences over the course of the last year. This enables us to share our products first hand and to keep on the cutting edge as to our community's technology needs. While we were thrilled at the excellent results from the recent SEE Flight Experiment Workshop in Huntsville, Alabama and the OTTI Workshop in Washington D.C., which the SEE Program hosted, we are proud to be co-sponsoring the 6th Spacecraft Charging Technology Conference on November 2-6, 1998 at Hanscomb Air Force Base in Boston, Mass. We are very excited about our first ever "Annual Highlights" publication which is due out by the end of 1998. This will be a straight forward publication which will share with the NASA SEE community the detailed accomplishments of the SEE Program in 1998. With the SEE Program Office's Sopo Yung's outstanding efforts, our SEE web-site continues to serve as a key element in our program as we average over 30,000 inquiries per month. The web-site provides the latest in SEE activities across the agency.

While many have played key roles in the many accomplishments of the SEE Program over the last few years, there are also new faces to the SEE Team. Ms. Janet Barth of the Goddard Space Flight Center recently accepted the position of co-chair of our Ionizing Radiation Effects Technical Working Group. Mr. Greg Olsen of the Marshall Space Flight Center now serves as co-chair of the Meteoroid Effects Technical Working Group and Ms. Jacqueline Townsend of the Goddard Space Flight Center serves as the co-chair of our Materials & Processes Technical Working Group. We are thankful to Tom Parnell, Pete Rodriguez and Dianne Stoakley for serving in these positions in the past, and we are excited about these new co-chairs as we work together to enter into a new era of technology development for NASA. Ms. Nikki Miller, who as secretary for the SEE Project Office and was the interface for many of you with the SEE Program and myself, has also moved on to other job opportunities and we wish her well in her endeavors.

So, as you can see, FY98 has been a very busy and hectic year for the SEE Program, and the SEE Program Office wouldn't have it any other way. As far as FY99 and our future, let me end with a good old southern expression. "If you can't get a fire started with this, your wood is all wet."

See You at the FINISH LINE,

Steven D. Pearson
SEE Program Manager

Mir Solar Array Experiment

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identify the molecular constituents deposited on the exterior surfaces of the solar cells. To further aid in identifying the contaminant films, EDX (Energy Dispersive X-Ray) spectroscopy measurements may be performed in the SEM (scanning electron microscope) to determine the elements present. Other investigations will include XPS (X-Ray Photoelectron Spectroscopy) and TOF/SIMS (Time of Flight/Secondary Ion Mass Spectroscopy). These measurements will made to further identify the elements and compounds present. In addition to these investigations, a profilometer will be used together with the dynamic SIMS technique to obtain depth profile measurements of the surface contaminants.

In addition to these laboratory investigations, bi-directional reflectance and fluorescence measurements will also be made by the investigators. When several individual solar cells from the selected sets removed from the panel are eventually sectioned and separated, visible transmission and solar absorption measurements will be performed of their individual components, and these data will be utilized to calculate the loss in power performance and energy conversion efficiency due to the presence of the contaminant films.

Editor's Note: The following U.S. Investigators are now participating in this unique, unprecedented analysis of Returned Russian flight hardware: James Visentine, Boeing; William Kinard, Langley Research Center; David Brinker, David Scheiman, and Bruce Banks, Lewis Research Center; James Zwiener and Rachel Kamenetzky, Marshall Space Flight Center; Keith Albyn, Johnson Space Center; and Thomas See, Lockheed-Martin

Miscellaneous

Coming in Winter 1999 Issue...

- *EMI Test Methods for Spread Spectrum*
- *Trapped Radiation Models: Uncertainties for Spacecraft Design*

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We are sending this issue to people we believe will be interested in the SEE Program. If you are not, please pass it on to someone else and let us know. Anyone interested in receiving the SEE Bulletin, may contact Ms. Belinda Hardin at:

E-Mail: *belinda.hardin@msfc.nasa.gov*
Fax: (256) 544-8807

Previous issues and current information can be found by visiting our homepage at:

http://see.msfc.nasa.gov/

Low-Altitude Trapped Radiation Model

The model predicts the integral omnidirectional proton flux in three energy ranges: >16, >36, and >80 MeV. It contains a true solar cycle variation and accounts for the secular variation in the Earth's magnetic field. It also extends to lower values of the magnetic L parameter than does AP8 thus addressing the major shortcomings of AP8.

The model is available by filling out the appropriate information on the SEE website at: http://see.msfc.nasa.gov/see/models/models.html

NASA/DoD Coordination Workshop for Radiation Tolerant Microelectronics and Systems for Space Applications

October 20-21, 1998

The purpose of the workshop is to investigate the issues associated with the long-term availability of radiation tolerant microelectronics for DoD and NASA applications. The objective of the meeting is to initiate an activity to increase the coordination of efforts between DoD and NASA, as well DOE and industry, in order to maximize future efforts in this arena.

For more information, please email: kwhetzel@pop200.gsfc.nasa.gov.

SEE Program Office
Mail Stop EL23
Marshall Space Flight Center, AL 35812

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